Library Hi Tech

The MobileMaker: an experiment with a Mobile Makerspace

Dana Gierdowski Daniel Reis

The MobileMaker: an experiment with a Mobile Makerspace

Dana Gierdowski and Daniel Reis
Elon University, Elon, North Carolina, USA

Received 26 June 2015
Revised 14 July 2015
Accepted 15 July 2015

Abstract

Purpose – The purpose of this paper is to discuss the design, implementation, and pilot of a Mobile Makerspace at a private, southeastern liberal arts institution that did not have a campus-wide makerspace. In an effort to give students in a residential hall access to maker tools and technologies and also meet the needs of a campus-wide writing initiative, a team of administrators and staff worked to build and design programing for the "MobileMaker," a pop-up Mobile Makerspace.

Design/methodology/approach – The authors explain how the equipment was chosen based on a variety of user skill levels. The technical specifications of the MobileMaker are also detailed, which includes 3D printing and crafting tools, and a variety of electronics. In addition, they explain how a mobile cart was modified to house and secure the equipment so it could be stored in an unsecured area. The team experienced several challenges with the MobileMaker project, including the overall durability of the mobile cart and the lack of a dedicated staff to manage the equipment.

Findings – The authors conclude that mobility and security were mutually exclusive with the mobile design that was chosen. Greater mobility was sacrificed to achieve greater security via locked doors and compartments that added weight to the cart. While the goal of increased student access to maker tools and technologies was met, the level of access was often limited due to staffing limitations.

Originality/value – An unanticipated outcome of the project was the conversations that were generated about the need and demand for a dedicated makerspace open to the entire campus community.

Keywords Writing, Constructionism, Self-directed learning, 3D printing, Makerspace, Mobile Makerspace

Paper type Case study

Introduction

The makerspace movement has grown in popularity in recent years, making its way in various forms on to higher education campuses. At some institutions, these spaces are frequently associated with disciplines related to computer science and engineering (Educause Learning Initiative, 2013), where they are situated within specific departments and programs. However, other colleges view them as sites of cross-disciplinary learning (Colegrove, 2013; Dougherty, 2013; Hlubinka *et al.*, 2013), and as such, physically place them within the larger ecosystem of the university with dedicated space that is not affiliated with a particular discipline or department. Hlubinka *et al.* (2013) noted that despite having roots in technical and vocational education, makerspaces depart by "metaphorically" and "sometimes literally, tearing down the walls between silos of classes […] in pursuit of a more interdisciplinary goal" (p. 5). For example, campus libraries are often chosen as the location for makerspaces, as they support goals and literacies across disciplines (Colegrove, 2013; Gustafson, 2013; Kayler *et al.*, 2013).

However, as many who work and study on higher education campuses can attest, space is often scarce and at a premium. This was the case in 2014 at Elon University, a private liberal arts university in North Carolina. Interest was growing among faculty, staff, and students, and fruitful conversations were taking place regarding the importance of creating a makerspace; in addition, some departments owned their own

Library Hi Tech
Vol. 33 No. 4, 2015
pp. 480-496

0737-8831
DOI 10.1108/LHT-06-2015-0067

3D printers for student use in their programs and majors. However, at this time there was no location available for a dedicated makerspace that was open to the wider campus community. As a result, the members of one of the university's residential neighborhood associations applied for an internal grant through Elon's campus-wide Writing Excellence Initiative (WEI) to fund a makerspace of their own. This paper discusses how administrators and staff members from multiple departments across the university came together to fund, design, and pilot the "MobileMaker," a pop-up, Mobile Makerspace[1], in an effort to give students in a residential hall on campus access to maker tools and technologies. In addition, it outlines the technical specifications of the equipment, the challenges the team faced with both design and implementation, and the future plans for the MobileMaker program.

The idea of the "MobileMaker"

Elon University is a private, mid-sized liberal arts university with the goals of engaging minds, inspiring leaders, and creating global citizens (Elon University Writing Excellence Initiative, n.d.). In 2013, the university officially launched the Writing Excellence Initiative (part of the college's accreditation requirements), a campus-wide project designed to prepare students to be excellent writers, focussing on the areas of writing to learn, writing in a discipline, and writing as a citizen. As a result of this Initiative, competitive funding opportunities were made available to the campus community for those who proposed projects that integrated and addressed the goals of the WEI. In the spring of 2014, representatives from an on campus neighborhood association[2] submitted a grant application requesting funds for a "mobile" makerspace. The neighborhood association drew on the expertise of the members of their group who worked in the university's Teaching and Learning Technologies (TLT) department for recommendations on what to include in the proposed MobileMaker, such as equipment and costs. Their proposal included electronics kits, a 3D printer, and other maker tools to be used by student residents for creative, technical, scientific, and entrepreneurial writing, composing, and creating. Residents in this community, comprised of approximately 600 students the majority of which were Performing Arts and Theater majors, did not have access to a 3D printer or maker tools on campus. In their grant application, they argued for specific equipment to outfit a makerspace in their community and noted several direct connections to the varieties of writing that aligned with the WEI that could be produced, including texts that facilitated visual communication in both 2D and 3D, reflective writing through a blog they would create related to their proposed makerspace, the writing of instructions, policies, procedures, assessments, and reports, publicity for the space, and the like. Due to space limitations in their area, as well as security concerns, they proposed that the equipment be available for checkout on a mobile cart that could be wheeled out into their common space and used by their residents as needed. When not in use, the maker cart would be stored in a secure room to maintain the existing common spaces to avoid overcrowding within the residence hall. Their proposal noted that all aspects of the maker cart would be led by their student RAs, including the authoring and enforcing policies, maintenance of the equipment, managing checkout, and supporting users. Due to the strength of their proposal and its alignment with the Initiative's goals, the funds were granted in the Spring of 2014, and members of TLT and the neighborhood association worked together to execute it.

Literature review

When planning and implementing a makerspace – mobile or otherwise – it is important to consider the current conversations taking place regarding the culture and theory of these sites and how they fit into the larger context of an institution. The planning team has drawn on several disciplinary areas that have informed (and continue to inform) the MobileMaker program at Elon, including theories and research related to maker culture, learning theory, writing, and composition studies, as well as mobile making programs at other institutions and sites.

Maker culture

The culture of a makerspace, as noted by Schrock (2014), is focussed on a flexible "openness" that supports its members as they move from "peripheral participants" to potentially "longstanding members engaged in ongoing projects" (p. 17). Drawing on Dewey's (1938) example of fine art, he argued that making or "hacking […] becomes not the domain of the elite or reified objects but intimately tied with everyday experiences throughout one's life" (p. 17). In her discussion of "Fabriken," a public makerspace in Sweden, Nilson (2012) pointed out that the core value of such a space is democratic inclusion; as such, allowing users from differing socio-economic backgrounds access to new technologies and maker tools makes room for "new thinking, learning, and acting which support[s] the process of social and technological innovation" (p. 294). With the lack of a makerspace on our campus in 2014, and with maker tools available only in certain departments (and thus, available only to certain individuals), users were in search of access to maker tools and technologies. It was our hope that through a Mobile Makerspace, we could increase access for new users and uphold the democratic philosophy so valued in maker culture.

Learning theory and making

While democratic access to maker technologies allows for new perspectives within the space, as noted by Nilson (2012), the depth of learning that takes place through the act of making is significant. In their book *Invent to Learn: Making, Tinkering, and Engineering in the Classroom*, Martinez and Stager (2013) argued that making and tinkering are "powerful form[s] of learning by doing" (p. 3). Inside the makerspace is where one sees contemporary learning theories that emphasize hands-on, experiential learning (Dewey, 1938; Kolb, 1984; Piaget, 1976) taking place. Today, Seymour Papert's concept of "constructionism" is often considered the most representative of the makerspace movement and culture, as users in these spaces use technology and tools to construct their own knowledge (Martinez and Stager, 2013). Broadening the theory of constructivism (from Piaget and others), Papert (1986) incorporated the use of materials and tools into the process. He noted that constructionists viewed "learning as a reconstruction rather than as a transmission of knowledge. Then we extend the idea of manipulative materials to the idea that learning is most effective when part of an activity the learner experiences as constructing is a meaningful product" (as cited in Sabelli, 2008).

While Paypert's work has been primarily situated in the discipline of computer science, scholars in other fields have long recognized the social nature of learning. For example, social constructivists in Composition Studies believe "individual writers compose not in isolation but as members of communities whose discursive practices constrain the ways they structure meaning" (Nystrand *et al.*, 1993, p. 289). The primary tenet behind this learning theory is that social interaction and participation, particularly with instructors, peers, and other members of the knowledge community, have a significant impact on learning (Chism, 2006; Lave and Wenger, 1991; Wenger, 1998). A number of scholars (Beichner *et al.*, 2007; Bruffee, 1998; Panitz, 1999) have noted the importance of peer interaction and collaborative learning in higher education. Lave (1991) asserted, "learning, thinking, and knowing are relations among people engaged in activity in, with, and arising from the socially and culturally structured world" (p. 67, emphasis in original). Panitz (1999) also emphasized the importance of collaborative learning:

> [Collaborative Learning] promotes mastery while passive acceptance of information from an outside expert often promotes a sense of helplessness and reliance on others to grasp concepts. In a typical college classroom that emphasizes lecturing there is little time for reflection and discussion of students' errors or misconceptions. In the CL paradigm, students are continuously discussing, debating and clarifying their understanding of concepts (p. 60).

Thomas and Brown (2011) have taken this concept further, asserting that a new learning culture has emerged based on the idea that transmission learning theory is incapable of keeping up with an ever-changing world; that peer-to-peer learning is more innate due to our access to new forms of media; and that "peer-to-peer learning is amplified by emerging technologies that shape the *collective* nature of participation with those new media" (p. 50, italics in original). Participation and interaction are important in a makerspace, as these inspire creativity and encourage peer-to-peer learning. These environments encourage dialogue and critique among users and offer different perspectives on creative processes (Gross and Do, 2009, p. 213).

Making and writing

The WEI administrators at Elon recognized a number of connections between the act of "making" and writing and saw opportunities to use the MobileMaker project to meet the campus-wide goal of creating excellent writers. Research on writing over the years has demonstrated that writing is a high impact practice of inquiry and discovery (Kuh, 2008) that involves interactive exchanges with writers and their audiences. In Engaging Ideas, John C. Bean (2011) draws on the work of rhetoric and composition scholars such as Wardle, Carter, Swales, and others to point out that different genres of writing can influence and construct how "certain communities think and act" (p. 48). Making or creating, much like writing, is process-oriented – it involves the drafting and composing of an artifact, trial, error, revision, and reflection. Members of the WEI team recognized similarities between maker culture and the growing conversations taking place in the areas of Rhetoric, composition, and digital media, particularly as these pertain to the often visual nature of the artifacts that are produced in different mediums. It has been argued in writing studies that we should challenge our ideas about what we consider as "texts" (Johnson-Eilola, 1998). Porter (2002) pointed out, "We are already in the age of new media, where visual and video forms of expression supersede alphabetic text" (p. 389). For example, a final product that comes from the act of "making" has the potential to speak or communicate in some way, much like an alphabetic text. As rhetoric and new media scholar David Sheridan (2010) wrote, "three-dimensional objects do indeed function rhetorically and may even possess their own distinctive rhetorical power. In fact, three-dimensional objects appear to play a unique role in fashioning culture itself" (p. 255). Much like the co-creation of knowledge that happens in a makerspace through trial, error, sharing, and co-working, knowledge is formed in writing classes through brainstorming and sharing of ideas, particularly in the process of peer review (Bruffee, 1998), which is considered a best practice in composition pedagogy in higher education classrooms.

"Mobile" making

While a dedicated, fixed location often comes to mind when one hears the term "makerspace," there is a growing trend of "pop-up" or "mobile" makerspaces. Researching Mobile Makerspaces and programs at other institutions and sites was a challenge, as the team found a dearth of literature in this specific area, adding to the complexity of building a piece of equipment that would suit our own contexts and needs. There are a number of different kinds of Mobile Makerspaces, such as castered/wheeled carts, modular "kits" that contain various maker tools, and vehicle-based spaces that are designed to be parked outside a building.

Since this project was launched, more has been written and published about different types of Mobile Makerspaces. For example, Vanderbilt University created a Mobile Makerspace for their children's hospital. The Project M@CH at Vanderbilt cart includes microcontrollers, a 3D printer, and other supplies and is moved around the hospital into patient rooms (Echegaray, 2015). The cart is very open and the equipment and supplies are visible and accessible to users. Such an open design makes sense for a cart that is moved around a building. However, rolling such a cart on sidewalks and through doorways might be jarring and potentially damage the equipment. While the original grant outlined a cart that would stay in the residence hall, we wanted to give ourselves the option of moving the cart to other buildings on campus. The design of Vanderbilt's Mobile Makerspace was driven by the fact that users would not be able to physically move to a fixed location. Their cart is wheeled into a room for a specific person to use and is not in a public space; thus, there was no need for lockable doors and compartments. In contrast, our MobileMaker needed doors to secure the equipment because the cart could be in a public location without supervision.

While the Vanderbilt equipment is on wheels, the Mobile Makerspace at Arrowhead Library System in Milton, Wisconsin has a different model. This makerspace is shared between seven public libraries and consists of several modules, each stored in its own plastic bin. When a librarian requests a module for their library, it is sent in a delivery bin from the branch that previously had it (Damon-Moore, 2015). Transporting equipment in bins makes sense for a makerspace that can be divided and moved between cities; however, this model was not feasible for the MobileMaker project because the team needed the equipment to be self-contained and available to be wheeled out for various events and use cases.

Vehicle-based makerspaces are another form of Mobile Makerspaces. For example, the "Geekbus" is a retrofitted bus that brings 3D printers, electronics, and other maker tools to schools in the San Antonio, Texas area. Geekbus is operated by the non-profit SASTEMIC and its goal is to encourage students to study the science, technology, engineering and math (STEM) fields (Geekbus, 2015). The advantages of these spaces are their mobility and the amount of space they afford for varying sizes of equipment. Vehicle-based makerspaces are typically built in a retrofitted bus, RV, delivery truck, or shipping container. Similar to book mobiles (Wiens, 2014), these Mobile Makerspaces move within a city or between cities, which increases access to a variety of uses in different geographic locations. However, this particular design did not serve our needs, as our MobileMaker needed to be situated (primarily) inside a residence hall and did not need to be moved off campus; thus, a vehicle-based makerspace would have been overkill for our project. As a result, the team adopted a "from scratch" approach given the needs of the users in the residential community and the space limitations therein.

Building the MobileMaker

Building the MobileMaker involved identifying a container and the components that would go inside it. The following sections outline the equipment that was chosen for the project and details about the cart selected to hold all the tools and machinery.

Decision-making: what should go in the MobileMaker?

The MobileMaker would not be a traditional makerspace, and as a result would not be able to support the many and various kinds of tools and machinery one might find in a typical, fixed makerspace. Thus, the planning team first had to decide what kinds of projects the MobileMaker should support. Whatever equipment was chosen, it would have to be small enough to fit inside a mobile container and light enough for someone to move in-and-out-of storage. The size and weight requirements limited the type of the equipment we could put in the MobileMaker. For example, large equipment like table saws and drill presses were not considered because of their size, as they would not fit in a container that could be easy to move in and out of storage.

Other popular tools that are often found in a makerspace, like laser cutters and some types 3D printer filament, can give off harmful fumes. In many makerspaces, those fumes would be captured with a ventilation system that blows the fumes outside. The MobileMaker design as proposed by the grant applicants would not have a permanent location, so connecting it to a ventilation system would not be practical or possible. The lack of a physical space also required that the kinds of tools in the MobileMaker not generate a mess (sawdust, metal shavings, scrap materials, etc.).

In addition, and perhaps most important, was the safety of the equipment, as students with beginner or novice-level maker skills would most likely be the primary users of the cart in the residential community. Unlike other higher education makerspaces that have dedicated areas which are often staffed with expert support technicians, the MobileMaker needed to be designed so that it could be used even if no support staff was available so as not to limit user access. As such, the team used the concept of "kitchen-level safety" – in other words, some of the chosen equipment could be dangerous if used improperly and presents a level of risk similar to a kitchen.

The equipment

Based on the above criteria, the team chose small, safe equipment, and tools that focussed primarily on 3D printing, electronics, paper cutting, and building sets.

3D printing tools. Students had limited options on campus for 3D printing and access to one in their residential neighborhood would increase the access to this technology. While the benefits of 3D printing varied, one of the drawbacks is the time it takes to print. As such, the convenience of a 3D printer in a residence hall made a lot of sense, as users could start their printing projects and still be nearby. The team chose several pieces of equipment necessary for 3D printing, including extra filament. A 3D scanner was also included, which can help users build a 3D model without needing to learn complex modeling software; that is, instead of having to learn 3D design software, students could scan a physical object and print it. Since there was no existing technical support staff, a one year extended warranty service plan was also added (Table I).

Electronics. Electronics and microcontrollers were essential to the cart, as these are often considered the building blocks to many projects and are popular in makerspaces. The planning team also recognized that most students were not likely to jump right into using tools that could potentially take hours to learn. With this in mind, electronic components and kits were chosen that required little to no training and allowed students to level-up and build upon their baseline skills (Table II).

For example, the cart houses "Makey Makeys," which is a simple electronic board that connects to a laptop through its USB port and can turn nearly any object into a computer key. For example, a user might connect the Makey Makey to a computer and five bananas. Each banana then works as a different key on a computer keyboard allowing one to play the piano on a computer through a link on the company's web site.

The MobileMaker also includes snap-together electronics called "littleBits." littleBits simplifies creating electronics by reducing them to their simplest parts: power, input, and output. They have a range of modules that can be snapped together to create many simple electronics. For example, one can create a very simple LED light that turns on when it detects motion by snapping together a power module, a motion detector module, and a LED light. This tool requires no coding-writing experience, and they snap together like Legos. Once a student reaches functional limits of the littleBits or Makey Makeys, based on the project, she can graduate to TinkerKits, LilyPads (see "Crafting" section below) or Arduino microcontrollers that allow for more customization, but require a more advanced understanding of electronics and coding (Table II).

Table I.
3D printing

Item	Description	Quantity
MakerBot Replicator II	3D printer	1
MakerBot service plan	Extended warranty for the 3D printer	1
PLA filament	Plastic for 3D printer	4
Sense 3D scanner	Handheld scanner to turn physical objects into 3D models	1

Table II.
Electronics

Item	Description	Quantity
Arduino microcontrollers starter kit	Open source prototyping platform for artists, designers, and hobbyists to create interactive objects. The starter kit includes common components and a book of projects	5
Tinkerkit – Scoula classroom pack	Based on Arduino, TinkerKits are modular and easier to learn than standard Arduino	1
LilyPad	An Arduino platform to be sewed into fabric	1
Makey Makey	A simple device that connects to a computer and turns nearly anything into keyboard keys	5
littleBits Synth Kit	Snap-together electronics that make musical sounds	2
LittleBits Student Set	Snap-together electronics	1
Bareconductive electric paint – 10 ml pens	Paint that conducts electricity	5
LED lights – red and blue – 50 packs	Lights to use with Bareconductive and Arduinos	2
Pin batteries – 50 pack	To power Bareconductive projects	1

Crafting: vinyl/paper cutting, building sets, and hand tools. The planners also wanted to attract students outside the STEM fields with equipment that required little to no advanced training or experience. The MobileMaker's primary location was to be in a residence hall comprised of students from diverse academic backgrounds. As such, the maker tools on the cart had to appeal to a variety of student interests and skills and reflect that diversity. For example, to attract students who might be more comfortable with crafting, the MobileMaker was outfitted with a vinyl cutter that precisely cuts vinyl, paper, and magnet sheets (Table III). The cutter requires no coding skills and can be used for scrapbooking, paper cards, and paper-based prototypes.

A number of the electronic tools can also be used in conjunction with the crafting tools to add electronic components to projects. For example, the "LilyPad" (Table II) is a version of Arduino that is meant to be sewn into fabric. The residence hall had a large population of students interested in theater and costume design, and the thought was that students already taking costume design classes would explore ways of adding electronics into their designs with LilyPads.

A "JIX" building set was also chosen for the cart, which is made up of plastic pieces that allow the user to connect drinking straws together. Much like Legos, these sets are easy to use but can be scaled up to create huge structures for conceptual design projects and idea generation (Table IV).

In addition, the cart also has a several hand tools (Table V), maker-related books with instructions, tutorials, and project ideas for Arduino and 3D printing, as well as books about tinkering and making.

Item	Description	Quantity
Silhouette CAMEO	Paper and vinyl cutter	1
Extra blade for CAMEO	Replacement blade for the vinyl cutter	1
Adhesive vinyl – 6 feet roll – various colors	Rolls of vinyl for the vinyl/paper cutter	4
Adhesive cardstock – 16 sheets	Sheets of thick cardstock with adhesive back	1
Magnet paper – 4 sheets	Sheets of magnetized paper	2
Transfer paper – 6 feet roll	Useful when transferring vinyl designs to other surfaces	2

Table III.
Vinyl/paper cutting

Item	Description	Quantity
JIX	Plastic connectors that allow you to build structures with drinking straws	4

Table IV.
Building sets

Item	Description	Quantity
Flush cut pliers	Primarily used to trim excess filament from 3D printed objects	2
Needle nose pliers	Primarily used to trim excess filament from 3D printed objects	2
Extension cord wheel – 4 pack	Extension cords to support the equipment that need power	1

Table V.
Hand tools and miscellaneous

The cart

Most of the components that were included in the MobileMaker were recommended by the TLT representatives and were outlined in the residential community's grant proposal; based on this equipment, the planners were able to approximate the size of cart that would be needed to house it all. However, other than to physically hold the equipment, the cart also needed additional features. The MobileMaker started with the idea that the members of the residential community required equipment that could be stored when not in use. Originally, the group planned on bringing out the cart for neighborhood events and keeping all the equipment in a single cart would make that easier. So the team decided on a big container that could store everything.

In order to promote the equipment and meet the initiative's goal of making writing and composing more visible across campus, the planners also wanted the option to move the MobileMaker to other buildings on campus. While this was not a part of the plan submitted in the grant application, the team thought having this option would make the equipment more versatile and allow it to reach more users. To allow for short, on campus trips, it was decided that the cart would need casters and doors; a cart on wheels would allow a few people to move the cart with greater ease, while lockable doors could prevent the equipment inside the cart from falling out during transport and allow it to be parked in a location without supervision.

After researching several options and programs, the planners quickly learned there was not an off-the-shelf solution for a Mobile Makerspace. Therefore, we purchased a mobile computer cabinet designed to hold a computer and monitor manufactured by Global Industrial and modified it to add more storage space and make it easier to change the 3D printer filament (see Figure 1).

The cart dimensions

Mobile security computer cabinet from globalindustrial.com

Overall unit
24-1/2"W×22-1/2"D×60-3/4"H

Upper compartment interior
24-1/4"W×21-3/4"D×21"H

Lower compartment interior
20-3/4"W×21"D×23-1/4"H

Locking slide-out keyboard drawer
19-1/2"W×17-3/4"D×4-1/4"H

Side cabinet dimensions

Optional side cabinet from globalindustrial.com
12"WX22-1/2"DX21-1/2"H

Side shelf dimensions

Optional side shelf from globalindustrial.com
12"WX22-1/2"D

Figure 1.
A front view of the MobileMaker

Modifications to the cart. In its out-of-the-box form, the cart did not provide enough space to store all the materials. Therefore, an extra cabinet was installed on the side to provide additional storage space for the 3D printer filament, rolls of paper, and reels of extension cords, while the top of the side cabinet was used to store the vinyl cutter (see Plate 1).

Eye bolts were then installed to securely hold the 3D printer and vinyl cutter to the cart; this modification allowed the cart to be moved greater distances without jostling and potentially damaging the equipment. The vinyl cutter is secured with an adjustable bungee cord, and the 3D printer is secured using a locking tie-down (see Plate 2).

Lastly, an access door was cut into the back of the cart to increase access to the 3D printer. This modification was needed to make changing the 3D printer filament easier. The filament is changed when a user wants to print with a different color or the spool runs out of filament. Without the access door, the 3D printer would have to be taken out of cart to change the filament. Handling the 3D printer is time consuming and increases the risk of damage (Plate 3).

Plate 1.
The additional side cabinet added storage space for materials. The vinyl cutter sits on top of the side cabinet and is secured with removable tie downs

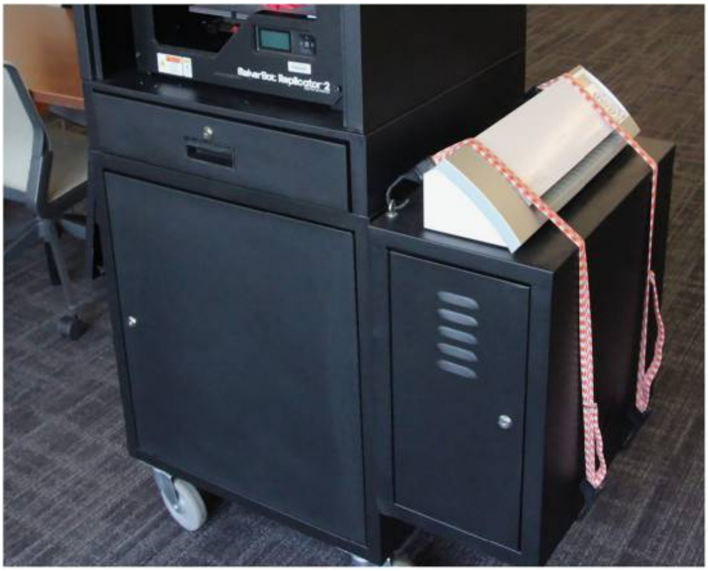

Plate 2.
Eye bolts and bungee cord were added to secure the vinyl cutter to the cart for transport

Plate 3.
The door on the back of the cart allows for easier access to the 3D printer filament

These modifications afforded additional on-board space for the maker tools and equipment, while also allowing for increased protection of the components when the cart needed to be transported within the residential community and beyond.

Implementation: MobileMaker programs and events

A number of programs and events were developed and implemented during the 2014-2015 academic year to promote the MobileMaker, both within the residential community itself and across campus. Over the year, representatives from the WEI, TLT, and the neighborhood association collaborated in various ways to offer programing and staffing support for the MobileMaker project.

In partnership with the residential community, the campus writing center funded the training and staffing of one of its student consultants for the project. This undergraduate consultant worked alongside a trained undergraduate RA from the residential community to learn how to use the maker technology and tools, offer support for new users in the residence hall, and support the writing that was outlined in the original grant application. In addition, the writing center consultant authored and published blog posts regarding the equipment and how students were using it for various projects.

The MobileMaker was featured at several events during the academic year in an effort to garner interest and increase its usage. The cart was exhibited in demonstration mode (where it featured the 3D printer at work) at several social gatherings open only to the residential community at various points over the semester. Other programing included a "Look What I Made!" contest open to all residents, which was coordinated and sponsored by the assistant director of the residential community during the university's winter term. In addition, over the year an RA staffer worked (by appointment) with a non-resident student majoring in entrepreneurship to assist him in designing and printing a series of prototypes, which he later pitched to a large-scale manufacturer. The neighborhood also had "open maker hours," which were set times the MobileMaker was staffed in the residence hall and available for use by anyone on campus. These "hours" were publicized to target audiences on campus including the residence hall itself, engineering and entrepreneurship majors and students, as well as related groups, such as the #MakeElon group (comprised of faculty, staff, and students), and science and engineering clubs.

The cart was also demonstrated and used at locations outside of the residential community throughout the year. These events were typically planned and sponsored through collaborations between the WEI, TLT, and the residential neighborhood representatives, and they varied in purpose and size. For example, during the fall semester the MobileMaker was moved a few blocks away to the university's student center and featured at a Residential Campus Initiative presentation, which was open to the greater campus community. Another campus-wide event that same term included the National Day on Writing[3], where the cart was exhibited in the writing center, which is located in the campus library. On this day, the Makerbot was programed to produce an object, and visitors were asked to think about how 3D printing might be considered a "composing" process and how the objects produced might communicate or make an argument.

Other programing outside the residence community included a partnership with #MakeElon – a group of faculty, staff, and students working to build interest in the construction of a physical makerspace at Elon open to the entire campus community. This partnership included events such as a 3D printing workshop where participants designed and had an option to print their creations, using the 3D printer on the MobileMaker. In addition, the #MakeElon group used many of the tools in the MobileMaker for a workshop through Elon's Office of Leadership and Professional Development, which helped introduce the principles of making to 25 faculty and staff. While these events took place outside the residence community, they were important in promoting the MobileMaker, supporting the Initiative's goals for writing, and building a larger awareness of the concept of making at Elon.

The neighborhood, writing center, and TLT also coordinated a partnership with an engineering faculty member for an introductory engineering course where students were required to design, print, and launch a model, custom-made rocket. In past sections of the course, the rockets were printed voluntarily by a faculty member in the computer science department, which was time consuming; in addition, the engineering students missed a learning opportunity to use a 3D printer and troubleshoot the subsequent issues related to the printing of their designs. Through the partnership, an RA from the neighborhood, TLT, and the writing center staffed the MobileMaker in the campus library, making it available over the course of several weeks at varying times as students worked on their assignment.

Challenges: equipment and management

In the design and implementation of the MobileMaker project, the team experienced several challenges related to the both the equipment itself and the administration and management of the program.

While the MobileMaker included many pieces of equipment, the cart chosen presented one of the biggest challenges to the project. There was not an off-the-shelf solution for a MobileMaker cart that met all of our requirements, so anything purchased would need to be modified. These modifications cost nearly $200 and took several days to complete. Ideally, the modifications would have happened in the summer, before the fall semester; however, these were delayed until October due to staffing availability. Very few events were scheduled before the cart underwent modification, which meant the MobileMaker was not as visible as it could have been during the first few weeks of the semester, and this lack of visibility could have affected its use.

Ironically, and despite all the efforts taken to make the cart mobile, the MobileMaker is not easy to transport due to its design and size. The cart is made of steel and, when filled with equipment, is very heavy and difficult for one person to safely move. Moving the cart over uneven surfaces (i.e. door thresholds and entry ways) and across the brick sidewalks on campus has taken its toll on the cart. Within the first year, the frame bent and lifted the wheels off the ground making it unsafe to roll outside. Thus, the MobileMaker has been side-lined in the campus library/writing center until it can undergo repairs. As of this writing, the MobileMaker is not very mobile.

The advantage of the design is that it is very secure. The steel doors and lockable cabinets meant the MobileMaker could be left on display in public places without worrying about equipment being stolen. However, one disadvantage of this design is that the security of the lockable doors also blocks the view of the equipment inside of the cart. Hiding the maker tools behind locked doors (even small ones) can prevent users from interacting with it. That is, for those who are unfamiliar or afraid of using this technology, visibility and exposure is important to demystify it for students (and others) and encourage use. In addition to this trade-off between security and visibility, we also experienced similar issues between mobility and security. The cart was very heavy and difficult to move, so it was not moved often. The steel exterior and locking doors secure the equipment inside but also added weight to the cart and made it less mobile.

In addition to some of the challenges with the equipment itself, the planners experienced several administrative complexities with managing the MobileMaker. In the original grant application, it was proposed that all aspects of the maker cart be managed by students in the residential community it served. However, staffing changes in the residential hall made realizing this vision difficult. For example, the staff members who conceived of and authored the grant proposal were assigned to other positions on campus before the MobileMaker was implemented in the fall of 2014. A new assistant director was also hired who adopted the responsibilities and duties associated with the MobileMaker; thus, he had to start fresh with the project that fall and quickly recruit a new undergraduate staff member to assist with the maintenance and technical support for users of the cart. Once found, the RA had limited availability to work hours supporting the MobileMaker due to other duties associated with her RA position. Although the staffer was able to offer support to some users via appointment, general access to the cart was affected.

The planning team also worked through logistical issues regarding the cart, such as where it was stored and when. In order to conserve space in the community's common space, the MobileMaker was typically stored in a smaller conference room that remained locked when not in use. As such, having the cart out of sight potentially affected user access and the frequency with which it was used.

In addition, representatives from the residential community noted that garnering interest with their residents and increasing the usage of the equipment was more difficult than anticipated. Despite featuring the cart at social events and marketing it within the residence hall via a maker contest, very few student residents signed up to use the equipment. While the goal of the project was to give a particular population of students access to maker tools, several months into the project the team realized the value of increasing access to users outside the residence hall. Once this was discovered, the team planned other opportunities for the MobileMaker to be seen and used in different locations on campus (see "Implementation" section above), which involved moving the equipment from the residence hall and as a result, put stress on cart.

Conclusion

Based on these experiences with the MobileMaker project, the team has come to several conclusions regarding how the equipment was designed, implemented, and managed. The biggest lesson learned regarding the equipment was that the choice of a "mobile" container matters a great deal in actually achieving mobility. We quickly learned that mobility and security were mutually exclusive with this particular "mobile" design; that is, one was sacrificed to get another based on the choice of cart. Had a different cart material been chosen, the MobileMaker would have been lighter, which would have put less stress on the frame and made it more mobile. For example, a rigid plastic cart with lockable doors would reduce the weight of the cart but would still allow the option of locking the equipment. The styles of doors could also make the equipment secure but encourage students to interact with it. Transparent doors, such as glass, plastic, or mesh, would let users see the interior of the cart while it's still behind a locked door. Thus, if security is a priority then locks and doors are required. If mobility is a primary concern, choosing a different material and removing the lockable doors would have reduced the weight of the cart.

The team is currently discussing the possibility of finding the MobileMaker a more public and fixed location in the residential community since it needs repairs and cannot be safely moved. With this approach, the MobileMaker would have a more stable home-base, which better aligns with the existing security features of the cart.

We also learned valuable lessons regarding the management and oversight of this kind of equipment. Providing trained technical support staff was important for users; however, for this project, it was at times difficult to make these experts available to users (due to student worker schedules, budget constraints, etc.). Thus, the team recognized the importance of having a dedicated staff member(s) who would be available to supervise the cart, assist others when it was in use, and promote the program itself. We found promotion to be particularly critical to encourage those familiar with the benefits of such technology (such as specific student groups, individuals, and classes); promoting the program (by way of marketing, workshops, administration, tech support, etc.) took time and human resources that were not already have in place.

To combat these challenges, the residential community is currently organizing two groups to help with the oversight, promotion, and support of the program by way of an advisory board and a support team. The vision for the MobileMaker advisory board consists of the area director, staff, and students to manage the processes for the presence and accessibility of the MobileMaker, while the MobileMaker support team will be comprised of five students to help with the day-to-day operations of the cart.

In reflection, we met some of our goals with the project and fell short on others. Students in the residential community had increased access to the equipment; however, the level of access was often limited due to staffing limitations. Goals regarding security of the equipment were also met, but the team ended up sacrificing mobility with the cart due to its heavy design. Although we experienced issues of mobility with the MobileMaker, awareness did increase in the residential neighborhood and across the greater campus regarding the benefits and versatility of maker tools. In addition to a greater awareness from individual students and groups, one of the unanticipated outcomes of the project was how it generated more conversations about the need and overall demand for a dedicated makerspace open to the entire campus community. The visibility and various programs and events of the MobileMaker also helped key decision makers on campus see that maker tools and technologies need not include the dangerous shop equipment found in a traditional workshop but can be suited to one's institutional context. As a result of this increased exposure, Elon's first fixed, campus-wide makerspace is opening in the 2015 academic year. While the MobileMaker project has helped key planners make practical decisions such as the kinds equipment, tools, and technologies that will be included in the new open makerspace, it has also taught us valuable lessons about makerspaces in general. That is, with this particular project, we learned that greater considerations must be given to planning, communication, and infrastructure in order to encourage and build the social interactions, peer-to-peer learning, and collective construction of knowledge so closely associated with a fixed makerspace.

Notes

1. For the purposes of our project, we are defining the "MobileMaker" as a secured, self-contained piece of equipment on wheels that contains various maker technologies and tools.
2. The neighborhood association includes the area director, resident assistants (RAs), faculty, and staff members from various departments on campus.
3. Typically held each October in communities and on campuses nationwide, the National Day on Writing is promoted by the National Council of Teachers of English, the National Writing Project, and the *New York Times Learning Network* to "celebrate writing in all its forms" (Source: www.ncte.org/dayonwriting).

References

Bean, J.C. (2011), *Engaging Ideas: The Professor's Guide to Integrating Writing, Critical Thinking, and Active Learning in the Classroom*, 2nd ed., Jossey-Bass, San Francisco, CA.

Beichner, R.J., Saul, J.M., Abbott, D.S., Morse, J.J., Deardorff, D.L., Allain, R.J., Bonham, S.W., Dancy, M.H. and Risley, J.S. (2007), "The student-centered activities for large enrollment undergraduate programs (SCALE-UP) project", in Redish, E.F. and Cooney, P.J. (Eds), *Research-Based Reform of University Physics*, Vol. I, American Association of Physics Teachers, College Park, MD, pp. 2-42.

Bruffee, K. (1998), *Collaborative Learning: Higher Education, Interdependence, and the Authority of Knowledge*, Johns Hopkins University Press, Baltimore, MD.

Chism, N. (2006), "Challenging traditional assumptions and rethinking learning spaces", in Oblinger, D.G. (Ed.), *Learning Spaces*, Educause, Boulder, CO, pp. 2.1-2.12.

Colegrove, T. (2013), "Editorial board thoughts: libraries as makerspace?", *Information Technology & Libraries*, Vol. 32 No. 1, pp. 2-5.

Damon-Moore, L. (2015), "Makerspaces on the move", Ideas+Inspiration, available at: http://ideas.demco.com/blog/mobile-makerspaces/ (accessed June 4, 2014).

Dewey, J. (1938), *Experience and Education*, Touchstone, New York, NY.

Dougherty, D. (2013), "Georgia Tech's Makerspace is a model for higher education", Makezine.com, available at: http://makezine.com/2013/03/28/georgia-techs-makerspace-is-a-model-for-higher-education/ (accessed May 6, 2015).

Echegaray, C. (2015), "Mobile 'makerspace' provides patients tools to create, inspire", *Research News @Vanderbilt*, February 5, available at: http://news.vanderbilt.edu/2015/02/mobile-makerspace-provides-patients-tools-to-create-inspire/ (accessed June 4, 2015).

Educause Learning Initiative (2013), "7 things you should know about makerspaces", April, available at: http://net.educause.edu/ir/library/pdf/ELI7095.pdf (accessed May 12, 2015).

Elon University Writing Excellence Initiative (n.d.), "Educating excellent writers at Elon", Elon, available at: www.elon.edu/e-web/administration/provost/qep/default.xhtml (accessed May 28, 2015).

Geekbus (2015), "About us", available at: www.geekbus.com/ (accessed June 4, 2015).

Gross, M.D. and Do, E.Y. (2009), "Educating the new makers: cross-disciplinary creativity", *Leonardo*, Vol. 42 No. 3, pp. 210-215, available at: https://wiki.cc.gatech.edu/designcomp/images/d/d7/Leonardo-New-Makers.pdf (accessed May 15, 2015).

Gustafson, E. (2013), "Meeting needs: makerspaces and school libraries", *School Library Monthly*, Vol. 29 No. 8, pp. 35-36.

Hlubinka, M., Dougherty, D., Thomas, P., Chang, S., Hoefer, S., Alexander, I., McGuire, D. and Vanderwerff, B.S. (2013), "Makerspace Playbook (School ed.)", Maker Media, February, available at: http://makerspace.com/wp-content/uploads/2013/02/MakerspacePlaybook-Feb2013.pdf (accessed May 4, 2015).

Johnson-Eilola, J. (1998), "Living on the surface: learning in the age of global communication networks", in Snyder, I. (Ed.), *Page to Screen: Taking Literacy Into the Electronic Era*, Routledge, London, pp. 185-210.

Kayler, M., Owens, T. and Meadows, G. (2013), "Inspiring maker culture through collaboration, persistence, and failure", in McBride, R. and Searson, M. (Eds), *Proceedings of Society for Information Technology & Teacher Education International Conference 2013*, AACE, Chesapeake, VA, pp. 1179-1184.

Kolb, D.A. (1984), *Experiential Learning: Experience as the Source of Learning and Development*, Prentice Hall, Englewood Cliffs, NJ.

Kuh, G. (2008), *High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter*, Association of American Colleges and Universities, Washington, DC.

Lave, J. (1991), "Situated learning in communities of practice", in Resnick, L., Levine, J.M. and Teasley, S.D. (Eds), *Perspectives on Socially Shared Cognition*, American Psychological Association, Washington, DC, pp. 63-82.

Lave, J. and Wenger, E. (1991), *Situated Learning: Legitimate Peripheral Participation*, Cambridge University Press, New York, NY.

Martinez, S.L. and Stager, G. (2013), *Invent to Learn: Making, Tinkering, and Engineering in the Classroom*, Constructing Modern Knowledge Press, Torrence, CA.

Nilsson, E.M. (2012), "The making of a maker-space for open innovation, knowledge sharing, and peer-to-peer learning", Malmo University, available at: http://medea.mah.se/2012/04/the-making-of-a-maker-space-for-open-innovation-knowledge-sharing-and-peer-to-peer-learning/ (accessed May 7, 2015).

Nystrand, M., Greene, S. and Wiemelt, J. (1993), "Where did composition studies come from?: an intellectual history", *Written Communication*, Vol. 10, July, pp. 267-333.

Panitz, T. (1999), "The motivational benefits of cooperative learning", *New Directions for Teaching and Learning*, Vol. 78, Summer, pp. 59-67.

Pappert, S. (1986), *Constructionism: A New Opportunity for Elementary Science Education*, Massachusetts Institute of Technology, Media Laboratory, Epistemology and Learning Group: National Science Foundation, Division of Research on Learning in Formal and Informal Settings, Cambridge, MA.

Piaget, J. (1976), *To Understand is to Invent: The Future of Dducation* (trans. by Roberts, G.A.), Penguin Books, New York, NY.

Porter, J. (2002), "Why technology matters to writing: a cyberwriter's tale", *Computers and Composition*, Vol. 20 No. 4, pp. 375-394.

Sabelli, N. (2008), "Constructionism: a new opportunity for elementary science education", *DRL Division of Research on Learning in Formal and Informal Settings*, pp. 193-206, available at: http://nsf.gov/awardsearch/showAward.do?AwardNumber=8751190 (accessed April 5, 2015).

Schrock, A.R. (2014), "Education in disguise: culture of a hacker and maker space", *InterActions: UCLA Journal of Education and Information Studies*, Vol. 10 No. 1, available at: https://escholarship.org/uc/item/0js1n1qg (accessed April 5, 2015).

Sheridan, D.M. (2010), "Fabricating consent: three-dimensional objects as rhetorical compositions", *Computers and Composition*, Vol. 27 No. 4, pp. 249-265.

Thomas, D. and Brown, J.S. (2011), *A New Culture of Learning*, CreateSpace, N. Charleston, SC.

Wenger, E. (1998), *Communities of Practice: Learning, Meaning and Identity*, Cambridge University Press, New York, NY.

Wiens, J. (2014), "Getting the fit right", *Policy Dialogue on Entrepreneurship*, November 10, available at: www.kauffman.org/blogs/policy-dialogue/2014/november/getting-the-fit-right (accessed June 4, 2015).

About the authors

Dr Dana Gierdowski is a Visiting Senior Program Coordinator for the Writing Excellence Initiative at the Elon University, where she manages projects for the Writing Center and the Writing Across the University program. She earned her PhD in communication, rhetoric, and digital media from the North Carolina State University, and in her scholarly work she explores how innovative, technology-rich learning spaces impact student writers and instructors. She has authored the book chapter "Studying Learning Spaces: A Review of Selected Empirical Studies" in the edited collection *Cases on Higher Education Spaces* (IGI Global, 2012) and is a Co-Author with Susan Miller-Cochran of the article "Making Peace with the Rising Costs of Writing Technologies: Flexible Classroom Design as a Sustainable Solution" in the March 2013 issue of *Computers and Composition.* Dr Dana Gierdowski is the corresponding author and can be contacted at: dcgierdo@gmail.com

Daniel Reis is an Instructional Technologist at the Elon University (Elon, North Carolina) where he works with faculty and staff to use technology in productive ways. He received a Masters of Information Science from the School of Information and Library Science at the University of North Carolina at Chapel Hill.